CASE STUDY: PASSIVE SOLAR CONCEPTS ADAPTED TO IN-FILL HOUSING IN A HOT, HUMID CLIMATIC ZONE

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ABSTRACT

In-fill housing for central city areas appears to be an answer to the continuing need for compact, affordable dwelling units that will improve the neighborhood environment. There exist many central city areas in Louisiana where lots are unusually narrow but zoned for residential use. As a result of current building code improvement programs, there are numerous vacant lots in the prime downtown locations. Owners and builders seem to be poorly equipped to deal with the design constraints inherent in architectural proposals for contemporary housing design in these areas.

This investigation considers the development of a case study that involves the planning and design of a compact, solar multi-family residential unit for a central city site condition. Emphasis will be placed on developing units that are highly energy conserving and have potential for one of three levels of passive solar technology--from a sun-tempered unit to a dominant passive solar system. The case study also focuses on the optional mix relationship between conservation options and passive system size. The site study area, a neighborhood in Baton Rouge, Louisiana, is distinctive in that narrow 40 x 100 feet lots predominate. Many are vacant.

INTRODUCTION

In-fill housing has been considered an effective

residential properties, or expanding the number of housing units on a site. In-fill housing can improve the availability and affordability of housing without contributing to urban sprawl. Some concern has been expressed that in-fill housing will displace lower-income residents or cause a decline in neighborhood quality. This study focuses on the potential for in-fill housing of a special type--low scale, multi-family housing that can accommodate the elderly and incorporate considerations of energy conserving technologies and passive solar system design.

The linear architectural form of housing known throughout Louisiana as the "shotgun"has been one of the most popular low-cost dwelling types. The shotgun can be found both in urban and rural areas of the state. This house-form style can be found in other places in the south as well, such as Louisville, Kentucky, and Chattanooga, Tennessee.

A popular explanation for the term "shotgun" house states that if a shot were fired through the front door of the house, the charge would pass through the interior openings and exit through the rear door. In practice this direct line of openings is not universal and is not found in many of the various forms of the shotgun house. It has been reported that in cities such as New Orleans after 1850 the houses of the working people were most likely to be of the shotgun type. Typically the shotgun house is only one room wide, long and narrow, with rooms arranged one behind the other (fig. 1).

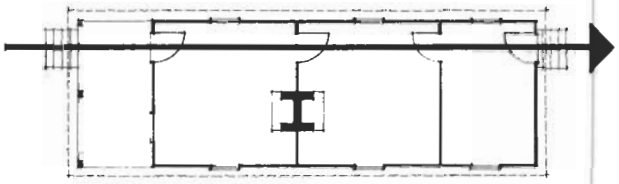

Figure 1. The "shotgun" concept.

This plan type fitted the narrow, long lots usual in working class neighborhoods of the cities. Over time, developers adapted the form and devised the double shotgun, housing two families, and the camel-back, a house unique to New Orleans with a second story above the rear part.

Throughout Louisiana the shotgun house is a traditional vernacular house form that has been used since the early nineteenth century. Many areas of cities and towns in the state have neighborhoods developed specifically for this house form (fig. 2).

As a result of recent building code improvement

-family or multiple family housing units. Individual land owners or developers appear to be poorly equipped to deal with the design constraints inherent in architectural proposals for a contemporary house form to fill these gaps.

The objective of this study is to discover the potentials and limitations of passive solar energy technology as it may be applied to in-fill construction of low-scale, multi-family residential units in a unique urban neighborhood located in a hot, humid climatic zone.

An area known as South Baton Rouge, located between the CBD and the university, provides an exceptional site for this case study. Existing zoning classifications permit a cooperative mixture of land use to occur--single family and multi-family residential units can be located in close proximity to one another. Approximately 20 percent of the lots in this area are vacant. Of the existing housing units, 41 percent are owner-occupied, 51 percent are renter occupied, and 8 percent are vacant. The majority of the lots are small, but the housing units generally have two or more bedrooms. Using the vacant sites

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or areas where sub-standard units are removed, this area could be developed to create more housing and spur economic growth within the community.

Figure 2. Site zoning.

This study involves the development of a series of case-study characteristic multi-family dwelling units. A unit to be considered for occupancy by an elderly individual is shown as an example. The linear form (shotgun) concept is used as it reflects both the predominant existing housing form and the vernacular style found throughout the city and the region.

Units may vary in size, form, materials, and methods and systems of construction. Emphasis is placed on developing units that have a potential for one of three levels of passive solar technology--from a sun-tempered unit to a dominant passive solar system. The result of the study is to determine those characteristic features that are most appropriate for this housing type and climate.

DESCRIPTION OF CHARACTERISTIC HOUSING UNIT AND SYSTEM

SITE

A distinctive feature of the site study area, a subdivision known as South Baton Rouge, is the predominance of narrow lots, most oriented with the major dimension east-west. The land parcels are generally 40' x 100'. Currently the area is zoned as "Limited Residential." The required minimum setbacks are as follows: front yard, 20 feet; side yards, 1/10 of lot width (4 feet), and rear yards, 20 feet. With a total area of 4000 sf, the buildable area is 1920 sf--48 percent of the available site.

Housing in this area consists chiefly of shotgun units occupied by single families. Many of the sites are vacant as a result of local code enforcement programs. One most unusual site characteristic exists--a 25-foot change in elevation across the site. This is a unique condition in South Louisiana in general (fig. 3).

CHARACTERISTIC BUILDING DATA

Geographical Data.

Location	Baton Rouge, LA
Latitude, degrees	30.5N
Elevation, feet	50

Figure 3. Site topography.

Climatic Data.

Heating Degree Days, annual	1650
Cooling Degree Days, annual	2999
January Minimum Temperature, °F	51.1
June Maximum Temperature, °F	90.3
Average Daily Range of Temperature, °F	20.5
Annual Average Daily Radiation, Btu/sf	1377

General Data.

Building Area, sf	1030
Building Cost (Estimate), $	36,820
Building UA Total	155
Building Volume, cf	9,865

Heating.

Area of Collector, SF	88
Solar Savings Fraction, f	.50
Auxiliary Heat Source	natural gas
Auxiliary Heat Requirement, MMBtu per year	4.18
Thermal Storage Heat Capacity Btu per degree	4,320

Cost Data.

Conservation	
Insulation	
Floor	$ 394.
Ceiling	559.
Walls	171.
Windows, Doors	2185.
Additional Wall Construction	1880.
	$5189.
Passive System	
Collector	1885.
Storage	3180
	$5065.

Characteristic Housing Unit. A prototypical lowscale, multi-family housing unit is shown as an

example (Figs. 4, 5). This unit was developed using a linear concept of spatial organization that is reminiscent of the common traditional house type developed for working-class people in New Orleans during the nineteenth century. The circulation spine may be considered synonymous to a gallery placed along one side of a shotgun. In this example, the unit is one of a four plex, having major openings oriented north and south. The conventional "living area" is located to the north, while a sitting area adjacent to a bedroom becomes the passive collector /storage mechanism--a direct gain system. Service and utility areas form a core for the unit. An ad-ditional sleeping area is located on a second level. This unit is proposed as a housing unit for an elderly occupant. The second bedroom provides a space for guests or for an in house health attendant.

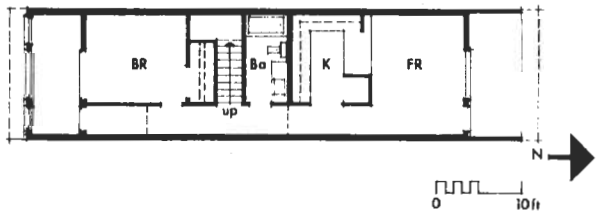

Figure 4. First Floor -- Plan.

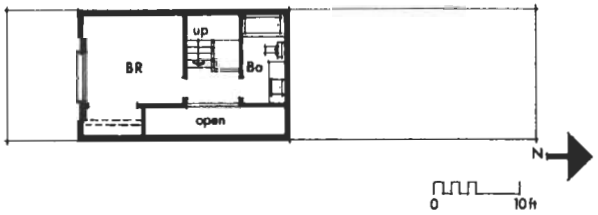

Figure 5. Second Floor -- Plan.

Construction. The intent here is to generate a form that can be built either with existing materials and methods of construction or with emerging techniques. For this prototype all of the materials are conventional building components.

Roof. Prefabricated wood roof trusses, 24" o.c., support the roof/ceiling loads. Insulation for the roof area is R-30 mineral fiber batts with a vapor barrier.

Walls. The wall separating individual units will be fire rated and with sufficient mass to decrease sound transmission. North and south opaque walls are 2 x 6 wood studs, 24" o.c., with R-19 insulation. East and west opaque walls are staggered 2 x 4, 24" o.c., with R-30 insulation. These walls have an aluminum reflective foil over a sheathing and a vented air space, approximately 1 1/2" in cross-section. These vents may be closed with a friction fitting insulation material during the heating season.

CONCLUSIONS

No attempt was made in this illustrative example to produce an optimal solution for the building systems. Further work is necessary to optimize both the passive solar energy system and the construction system.

There remains a number of questions regarding the use of the in-fill housing concept, both in general and in particular at a given site. Even where sites are available, community attitudes toward the concept still reflect a preference for single-family residential units. Research efforts are needed to address these larger scale issues of community attitudes, regulatory obstacles, and other related issues, With respect to passive energy technologies there is a need for continuing studies relating comfort considerations to both design and construction of the low-scale multi-family housing unit, especially in a hot, humid climatic zone. Energy conservation technology involving the reduction of envelope loads and infiltration are available for most residential building types. Reductions in sensible loads, both for heating and cooling considerations are possible. Ventilation and humidity, however, still pose a problem for passive solar building design. There is a need to understand how these technologies affect the building occupants' concept of thermal comfort and the limits of design concepts or materials and system technologies.

Experience gained from this study can lead to a better comprehension of the issues involved in producing an affordable housing unit for this environment.